Suggested Actions

- Conduct a voltage drop survey. The voltage drop is simply the voltage difference across the connection. Voltage drop information can be used to determine energy losses and excess energy consumption due to loose and dirty connections. Voltage-drop measurements should be taken at each phase. The total energy loss in a three-phase component is determined by summing the losses for each phase. Limit the load on each circuit or install larger-than-code-minimum conductors if the voltage drop exceeds 3%.

Resources

U.S. Department of Energy—Contact the EERE Information Center at 877-337-3463 to obtain cited publications or to request additional information on motor and driven-equipment energy efficiency opportunities. Additional resources and information on training is also available at the BestPractices Web site at www.eere.energy.gov/industry/bestpractices.

Eliminate Excessive In-Plant Distribution System Voltage Drops

Studies indicate that in-plant electrical distribution system losses—due to voltage unbalance, over- and under-voltage, low power factor, undersized conductors, leakage to ground, and poor connections—can account for less than 1% to over 4% of total plant electrical energy consumption. In a study at three industrial facilities, average electrical distribution system losses accounted for 2% of plant annual energy use. Losses due to poor connections represented one-third of these losses and accounted for 40% of the savings after corrective actions were taken.

Poor connections or inadequate conductor sizes result in excessive energy losses. The increased resistance converts electrical energy into heat and imposes additional loads on the distribution system. Maintenance of connections is generally referred to as termination maintenance. Termination maintenance is generally a cost-effective electrical distribution system energy savings measure.

Causes of poor connections include:

- Loose cable terminals and bus bar connections
- Corroded terminals and connections
- Poor crimps
- Loose, worn or poorly adjusted contacts in motor controllers or circuit breakers
- Loose, dirty, or corroded fuse clips on manual disconnect switches

Distribution system losses due to poor electrical contacts appear as hot spots caused by increased resistance or electric power (I^2R) losses. These hot spots may be detected by infrared thermography or a voltage drop survey. Inexpensive hand-held infrared thermometers can quickly and safely reveal hot spots.

Terminations should be regularly inspected. Replacing fuse clips or cleaning breaker fingers can be very cost-effective. The cost of cleaning or replacement is low compared to the significant energy savings and secondary benefits, including reduced downtime due to unscheduled equipment outages and improved safety due to reduced fire hazards.

Conducting a Voltage-Drop Survey

A voltage-drop survey can usually be done in-house with existing equipment such as a hand-held voltmeter. Voltage drop measurements should be taken from the input of each panel to the panel output for each load. For a typical motor circuit, measure the voltage drop from the bus bar to the load side of the motor starter. Compare the magnitude of the voltage drop for each phase with the voltage drop for the other phases supplying the load. A voltage drop difference of over 15% indicates that testing should be initiated to identify poor circuit connections. Even with good balance, an excessive voltage drop indicates that component voltage drop testing should be initiated.

Energy Savings Example

Measurements at a motor control center (MCC) breaker indicate voltage drops of 8.1, 5.9, and 10.6 volts on L_1, L_2, and L_3, respectively. The driven equipment is continuously operated. Measured line currents are 199.7, 205.7, and 201.8 amps for L_1, L_2, and L_3. Voltage drop measurements for circuits serving similar loads indicate that a voltage drop of 2.5 volts should be obtainable. The potential annual energy and electrical demand savings due to correcting the problem are:

Table 1 Excess Energy Consumption at a MCC Breaker

Circuit	Measured Voltage Drop, Volts	Excess Voltage Drop, Volts	Current, Amps	Excess Power, kW	Excess Energy Use, kWh
L_1	8.1	5.6	199.7	1.12	9,796
L_2	5.9	3.4	205.7	0.7	6,126
L_3	10.6	8.1	201.8	1.63	14,318
Totals:				3.45	30,240

Assuming a utility energy charge of $0.05/kWh with a demand charge of $8.00/kW per month, potential savings are valued at:

Savings = 3.45 kW x $8.00/kW/month x 12 months/year + 30,240 kWh/year x $0.05/kWh
= $331 + $1,512 = $1,843 per year (for a single breaker)

References

This tip sheet is extracted from two publications prepared for the Bonneville Power Administration: *Industrial Electrical Distribution Systems Study Report* and *Keeping the Spark in Your Electrical System: An Industrial Electrical Distribution Maintenance Guidebook*.

About DOE's Industrial Technologies Program

The Industrial Technologies Program, through partnerships with industry, government, and non-governmental organizations, develops and delivers advanced energy efficiency, renewable energy, and pollution prevention technologies for industrial applications. The Industrial Technologies Program is part of the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy.

The Industrial Technologies Program encourages industry-wide efforts to boost resource productivity through a strategy called Industries of the Future (IOF). IOF focuses on the following eight energy and resource intensive industries:

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum
- Steel

The Industrial Technologies Program and its BestPractices activities offer a wide variety of resources to industrial partners that cover motor, steam, compressed air, and process heating systems. For example, BestPractices software can help you decide whether to replace or rewind motors (MotorMaster+), assess the efficiency of pumping systems (PSAT), compressed air systems (AirMaster+), steam systems (Steam Scoping Tool), or determine optimal insulation thickness for pipes and pressure vessels (3E Plus). Training is available to help you or your staff learn how to use these software programs and learn more about industrial systems. Workshops are held around the country on topics such as "Capturing the Value of Steam Efficiency," "Fundamentals and Advanced Management of Compressed Air Systems," and "Motor System Management." Available technical publications range from case studies and tip sheets to sourcebooks and market assessments. The Energy Matters newsletter, for example, provides timely articles and information on comprehensive energy systems for industry. You can access these resources and more by visiting the BestPractices Web site at **www.eere.energy.gov/ industry/bestpractices** or by contacting the EERE Information Center at **877-337-3463** or via email at **www.eere.energy.gov/informationcenter/.**

BestPractices is part of the Industrial Technologies Program Industries of the Future strategy, which helps the country's most energy-intensive industries improve their competitiveness. BestPractices brings together emerging technologies and best energy-management practices to help companies begin improving energy efficiency, environmental performance, and productivity right now.

BestPractices emphasizes plant systems, where significant efficiency improvements and savings can be achieved. Industry gains easy access to near-term and long-term solutions for improving the performance of motor, steam, compressed air, and process heating systems. In addition, the Industrial Assessment Centers provide comprehensive industrial energy evaluations to small- and medium-size manufacturers.

FOR ADDITIONAL INFORMATION, PLEASE CONTACT:

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